Procedure Manual For
Surveying Aquatic Vegetation:
Tier I Reconnaissance Surveys

1. Surveying Strategy for Aquatic Vegetation

This procedure was developed to serve as a **qualitative** surveying mechanism for aquatic plants. This protocol will serve to meet the following objectives:

1. to provide a distribution map of the aquatic plant species within a waterbody
2. to document gross changes in the extent of a particular plant bed or the relative abundance of a species within a waterbody

This survey strategy may be augmented with the Tier II Aquatic Vegetation Sampling Protocol to gain more quantitative data if desired.

1.1 Introduction to Aquatic Plant Surveying

Surveys of aquatic vegetation are important to managers and researchers for habitat inventories, diagnosis of problem areas, detection of nuisance and/or exotic species, and in the development of aquatic vegetation management plans. Many levels of surveys may be completed from visual observation to highly quantitative, repeatable strategies. The major advantage of visual qualitative survey methods is the relatively small amount of time required to complete a survey. The standardization of a reconnaissance survey procedure will allow for more precise information to be collected. This increase in precision will occur as standardization allows many people to produce more similar results over time. The methods described below are designed to provide a standard rapid assessment of aquatic plant communities within a given waterbody. The following text, tables, figures and datasheets will strive to meet the goal of standardization. A quick and easy reconnaissance protocol may increase the number of repeatable future surveys leading to a greater understanding of aquatic plant distributions and changes within the state.

1.2 Interpreting Reconnaissance Surveys

Distribution maps generated from a Reconnaissance Survey may be converted to surface area information using standard map measuring techniques (i.e., compensating polar planimeter, digital software, or scaled grids). Measurement of surface area allows for rough quantification of the information collected during the survey. These data may be compared between species, seasons, and years to allow for development of conservation and management plans. However, it is important to remember that visual measures of abundance are highly subjective and data are more valuable if subjectivity can be reduced by better defining commonly used abundance descriptions (e.g., “rare” = <2% of the community). For this reason, in water bodies with low water clarity that prevents visual identification of plant species, rake throws are conducted to allow species identification.

1.3 Habitat Stratification

The types of areas/waterbodies commonly surveyed are divided into strata and subjected to discrete surveying efforts to increase efficiency, effectiveness, and knowledge of habitat influence on plant communities. Each stratum represents a major aquatic geomorphic feature in the State of Indiana (Table 1). A few other strata are not typically surveyed. The main navigation channel on the Ohio River and other deepwater areas within selected lakes or rivers (>6 m deep) are not surveyed because aquatic vegetation is unlikely to grow in these areas in the prevailing water quality conditions. In addition, the aquatic areas near dams and/or spillways are not surveyed because of safety considerations. Refer to Table 1 when categorizing the surveyed stratum.

Table 1. Aquatic Area Strata and Codes

Stratum Description	Stratum Code
Inland Lake	IL
Inland Reservoir	IR
Lake Michigan	LM
First Order Stream	FOS
Second Order Stream	SOS
Third Order Stream	TOS
Fourth Order Stream	FROS
Fifth Order Stream	FHOS
None	NA

* When "None" is selected, describe the habitat type in the comments section of the data sheet.

2. Equipment

2.1 Maps

A high-resolution bathymetric map is used as the base map when available. Potential map sources also include: printouts from digital sources, USGS 7.5 minute topographic maps, aerial photos, production of a map with a stadia rod and sighting compass, or a hand drawn sketch of the lake.

2.2 Field Equipment & Explanation

A. Boat
B. Safety Equipment (e.g., life jackets)
C. Frodis (i.e., rake, anchor, or other sampling device w/ rope)
D. Lake map
E. Waterproof pens, pencils, or markers
F. Plastic bags for collection of unknown plants
G. Polarized sunglasses
H. Secchi disk (optional)
I. Range finder (optional)
J. GPS unit (optional)
K. Depth detection device (e.g., sounding line, depth gun, sonar; optional)
L. Aquaview (looking glass; optional)

A boat or canoe is needed to survey the lake. Any safety equipment that is required by law (U.S. Coast Guard or state law) should also be carried on board. A frodis is needed to periodically collect plants from deeper water areas and below canopies when visual inspection does not allow species determination. The lake map is marked with plant bed numbers and approximate boundaries to help distinguish plant beds of different species and/or groups of species within the lake. A unique datasheet will correspond to each plant bed number on the map for further explanation of that particular plant community. A Secchi disk will help determine the depth at which plants can be seen and will help define the littoral region. A range finder is helpful in determining distances from shore to more accurately map vegetation. If available, WAAS-enabled GPS units should be used to determine locations of plant beds and perimeters of plant beds using tracks and/or waypoints. Coordinates may be uploaded to computers to map vegetation beds for permanent record and help in the determination of surface area of vegetation. Coordinates may also be plotted on scaled maps using map grids. A depth detection device may be used to determine the extent of the littoral region including shallow shoals offshore where aquatic vegetation may grow. Some sonar device models may also help determine the maximum depth of macrophyte growth. A looking glass may be used to more clearly see vegetation below the surface. Polarized sunglasses are a necessity as they greatly improve one,s ability to see below the surface and distinguish plants, thus reducing

the number of rake tosses that are needed. Finally, plastic bags are on hand for the collection of unidentified species.

3. Preparation

3.1 Pre-survey Information

Prior to entering the field, information should be gathered on the lake being surveyed. Valuable information includes lake size, maximum depth, historical species lists (if available), and historical Secchi depth data. Sources for this information include the Indiana Department of Natural Resources' regional fisheries biologists, diagnostic study reports, websites (IDNR, IDEM, & IU), and other sources. The size and depth of the lake can help determine equipment needs and the amount of time needed to complete a survey of the lake. While survey time is often correlated to lake size, it is more closely related to the shoreline length and/or area of the littoral zone (i.e., large lakes with many coves have a greater shoreline length). **The acceptable sampling period extends from 15 June to 15 September. If resources are limited to a single reconnaissance survey, then the surveys should be conducted between 15 July and 31 August;** however, secondary surveys are recommended to catch temporal variations in plant communities. Also, depending on the intent of the survey, some *partial* lake surveys may be conducted.

3.2 Determination of Littoral Zone

The entire littoral zone of a lake should be briefly examined during a Reconnaissance Survey. Determination of the littoral zone is important for management and mapping of vegetative cover within a lake. The littoral zone is defined as the region of a lake from shore to a depth where vegetation disappears. In lakes with relatively shallow secchi depths the 1% light level may be approximated by multiplying the secchi depth by a factor of three. Most macrophyte species will not grow to the 1% light level, only algae and primitive plants. In extremely clear lakes macrophytes are generally restricted by hydrostatic pressure, rather than light, to a depth of 6 m (19.7 ft.) but some species may grow deeper. Eurasian watermilfoil has been found to grow to a depth of at least 9 m (30 ft.) while elodea has been found growing to a depth of 12 m. Isoetes (quillwort) has been found to grow to a depth of 15 m (~50 ft.) or more in clear lakes.

The littoral zone of a lake, for purposes of a standard Reconnaissance Survey, is defined as the area from the shoreline to a depth equal to three times the known (or average) Secchi depths.

4. Surveying

4.1 Survey Coverage

Once the littoral zone of a lake has been determined, the survey can begin. The boat path should include a zig-zag pattern through the littoral region of the lake. Lakes that drop off quickly may only need one path along shore. In areas where the littoral region extends far from shore, several passes may need to be made in a zig-zag pattern. **These passes should never be farther apart than can be visually inspected.** For instance, if a bed of vegetation extends to the surface and it is visible from one side to the other, there is no need to make multiple passes through this area. However, in areas of dense canopies an effort is made to determine if any species are growing below the canopy. (This may include one to a few rake tosses.) Each unique plant bed requires a unique datasheet to be completed (See Appendix A). Any off-shore shoal areas that have a depth less than the maximum littoral zone depth are surveyed as well (an additional datasheet compiled for each). A cover datasheet is completed for the waterbody as a whole and all individual plant bed datasheets are then attached to the waterbody coversheet.

Once approximately 50% of the shoreline areas are surveyed, a determination is made on the detail needed to survey within the remainder of the littoral region. It is important to sample areas that provide different habitat for plants (e.g., points, coves, shores with different features). Different shorelines attributes (e.g., face north, south, etc.) often contain different species (e.g., plants that sprout from fragments will often be more abundant on the windward side of a lake). In a lake with many species growing in relatively small beds, the littoral zone is examined more carefully than a lake with dense monoculture stands that cover large areas.

The time associated with a survey varies based upon factors noted above and the experience of the survey team. As much detail is collected as time allows. In general, most surveys completed using this protocol will take anywhere from one to six hours to complete. The amount of time required is affected by the diversity of the plant beds and the amount of littoral region, more so than the lake size. Shoreline length also greatly affects the time needed to complete a Reconnaissance Survey. Generally, two to four miles of shoreline can be surveyed per hour. However, if the littoral region is narrow and/or diversity is low, a much greater distance is surveyed per hour. Lakes less than 300 acres require approximately 1 hour per 100 acres. Lakes greater than 300 acres generally decrease in the time required per 100 acres. Lakes as large as 800 acres may be completed 4 to 6 hours assuming the entire lake is not littoral region. It is important to gather and review lake maps ahead of time since they provide the survey team with valuable information related to depth contours, shoreline length, and lake size; thus, allowing the team to devote an appropriate amount of time to the survey.

4.2 Vegetation Mapping & Data Recording

The survey technique utilizes a combination of intense visual examination and limited rake grabs to identify the abundance of aquatic species in individual plant beds. The individual plant bed survey area is defined as a contiguous, consistent (similar composition) community. This survey site/bed is then surveyed in its entirety. If the community composition changes dramatically while surveying what appears to be a contiguous bed, prepare individual datasheets for the different communities and note their approximate boundaries on the attached map.

A cover sheet is completed for each waterbody. Individual site data sheets for a given plant bed are then attached to the waterbody cover sheet. A new site data sheet is started for each plant bed in the waterbody. The surveys sites/beds are numbered counter-clockwise around the waterbody beginning with "01", and remain the same from year to year (as much as possible). Information about each plant bed appears in its entirety on a single page. When there is not enough room remaining on a page to complete the listing for a bed, a new page is started. **All numbered survey sites/beds have approximate boundaries sketched on a corresponding map and labeled with their unique number, such as "01".**

The data sheet (Appendix A) is divided into four sections, **Site information**, **Site Coordinates**, **Species information**, and **Reminder information**. The **Reminder information** contains the data choices to be entered in the major data fields (boxes). All data fields on the data sheet are explained in detail in Appendix B.

The surveying operation is composed of multiple steps, beginning with recording **Species information**. Steps 1–4 are to collect **Species information.** Steps 5–8 are to complete **Site information and Site Coordinate information**.

Step 1. After a survey site/bed is reached, a site number, such as "01", is recorded in the **Site ID** box of the **Site Information** section. This step signifies the beginning of the **Species Information** section. Travel in zig-zag pattern through the plant bed (See Figure 1). Record the species code (Appendix C) for all species in the **Species code** box and assign a visual abundance rating (in the **Abundance** box) for every submersed, rooted floating-leaved, non-rooted floating-leaved, emergent species, and alga observed. Assign abundance ratings based on the increments outlined in Table 2. These ratings essentially represent a percent cover measurement. If the canopy is dense or visibility is too poor for accurate visual identification of species, make sufficient rake throws to determine the occurrence of all species.

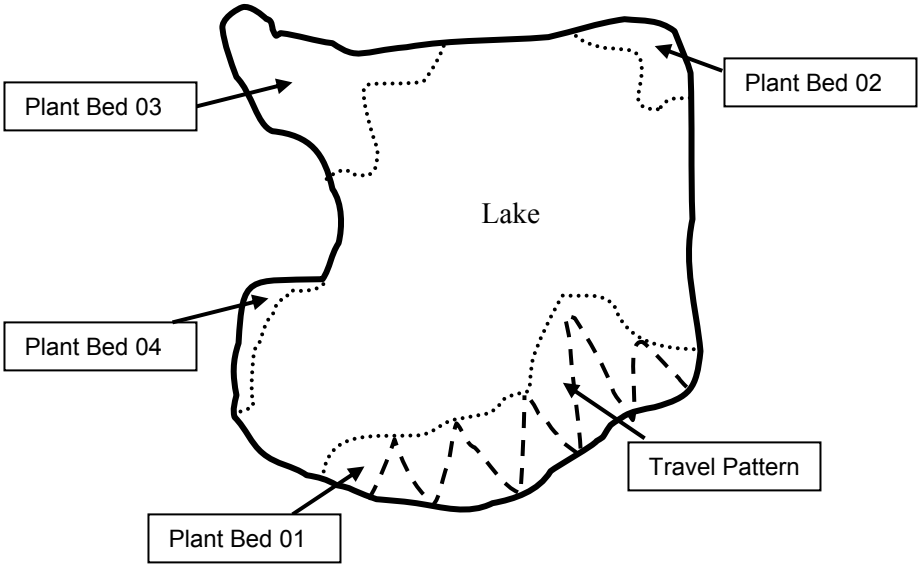

Figure 1: Depicts a potential travel path around a lake for purposes of a Reconnaissance Survey.

Table 2. Visual Abundance Ratings

Abundance (%)	Cover rating
> 61	4
21-60	3
2-20	2
< 2	1

Step 2. If the choice of species code fits the definition in Appendix B, assign a QE code of "0". Otherwise, assign a code according to Table 3 in the **QE** box to flag each uncertain choice of species code. **Voucher specimens are collected for any species of which the identity is uncertain or unknown, or a species that is known not to be in the state herbarium.**

Table 3. Plant identification quality evaluation codes

Identification certainty	*QE* code
Species code follows the definition in Appendix B	0
Genus certain, species suspected	1
Both genus and species suspected	2
unknown	3

Step 3. If a specimen is collected, a 1 is recorded in the **Voucher** box otherwise a "0" is recorded. If the specimen is sent to a taxonomist for identification, the 1 is later amended to a 2 to serve as a reminder that identification is pending. Comments about that site (unusual situations, species taken for identification or the presence of endangered, threatened, or rare (ETR) species) are written in the **Comments** section by the data recorder. If available the latitude and longitude location of any voucher specimens collected or the location of ETR species is also recorded in the comments sections. Voucher

specimens should include multiple specimens of the same species (3-5 specimens with all available morphological characteristics, flowers, fruits, etc.)

Step 4. After reaching the perimeter of the plant bed, sketch the relative size and location of the individual bed on an attached lake map. Record the corresponding **Plant Bed ID** number on the map. It is also possible to assign a unique reference number/letter to denote the approximate location of a species of special interest on the map. Record this number/letter on both the map and the data sheet (**Ref. ID** box).

The area of the plant bed may be drawn onto the map with some accuracy if shoreline points of reference (e.g., points, docks, etc.) are used to determine your location on the lake. GPS units and rangefinders may also increase the accuracy of these sketches.

Step 5. After having surveyed the extent and composition of the plant bed, visually estimate by life form the percentage canopy cover of nonrooted floating-leaved, rooted floating-leaved, emergent, and submersed canopy species in the bed. Rate the percentage cover of the canopy species according to Table 4, and record the ratings in the appropriate **Canopy** box. (Note: Emergent, rooted floating-leaved, and nonrooted floating-leaved plants intercept sunlight at or above the water surface and may shade submersed plants growing in the water column, therefore, the percent canopy is important site information.) The rating should reflect the abundance of these life forms throughout the entire plant bed and serve to summarize the canopy cover and composition for the bed.

Table 4. Vegetation Canopy Ratings

Cover (%)	Cover rating
> 61	4
21-60	3
2-20	2
< 2	1
None	0

Step 6. For those plant beds where invasive species are present, rake throw sampling should be conducted to quantify the degree of infestation. The number of rake throws required depends upon the homogeneity of the plant bed. In plant beds highly dominated by one species, as few as three throws may be sufficient if the results are the same each throw. Alternatively if each rake throw has plant species compositions that vary, then a larger number of rake throws will be required (e.g., 4-5 throws).

Step 7. Record the number of rows with information (from the **Species information** area) in the **Total # of Species** box at the top pf the data sheet.

Step 8. Return to the approximate center of the plant bed and record GPS derived latitude and longitude coordinates and record the coordinates in the **Site coordinates** area of the data sheet. (A map grid may also be used to determine latitude and longitude coordinates if GPS is not available.) If appropriate, also record the GPS derived latitude and longitude coordinates for the location that defines the furthest lakeward extent of the plant bed. Note the approximate locations of both points with an "X" on the attached plant bed map.

Step 9. Repeat steps 1 to 8 for each plant bed surveyed. Remember to start a new data sheet for each new bed encountered.

5. Post Survey Analysis

All waterbody summary information and GPS metadata is recorded on the **Waterbody cover sheet.** Datasheets are completed to the greatest extent possible following the survey. The map is completed with all relevant information and plant beds drawn. The surface area (acres) of each plant bed is determined and recorded in the **Bed Size** box on the data sheet. When gross historical changes in species composition, dominant species, and surface coverage are observed from year to year, notes are added to the **Comments** section.

6. Data & Equipment Management

All data sheets are identified with the sampling organization's name and crew leader and recorder names. Photocopies are made of all data and log sheets. The photocopied data sheets are mailed to the Department of Natural Resources Division of Fish & Wildlife. All originals are retained by the sampling organization.

Endangered, threatened or rare species are recorded on the data sheet and approximate locations noted on the map through the use of the **Reference ID** box (See Step 4). The presence of such species should also be recorded on the Indiana Special Plant Survey Form (See Appendix A) and sent to the IDNR Division of Nature Preserves.

Voucher specimens are collected and directed to the attention of Dr. Robin Scribailo at Purdue-North Central.

To avoid the spread of exotic species, survey crews should insure that all traces of aquatic vegetation are removed from boats, motors, and sampling gear before surveying other lakes/streams.

7. References Cited

Blackburn,

Yin, Y., Winkelman, J.S., and H.A. Langrehr. 2000. Long Term Monitoring Program procedures: Aquatic vegetation monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, LTRMP 95-P002-7. 8pp. + Appendices A-C.

Aquatic Vegetation Plant Bed Data Sheet

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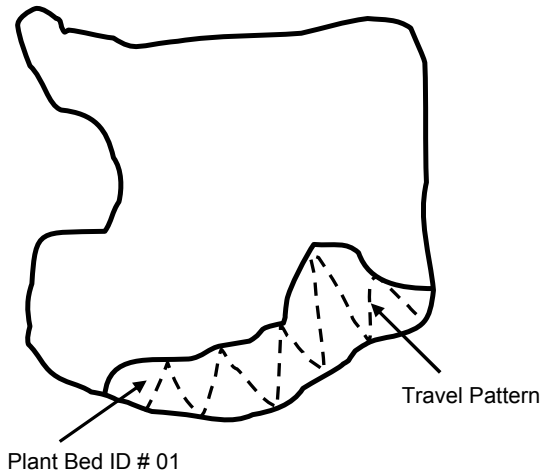
State of Indiana Department of Natural Resources

ORGANIZATION:					**DATE:**
SITE INFORMATION					**SITE COORDINATES**
Plant Bed ID:	Waterbody Name:				Center of the Bed
Bed Size:					Latitude:
Substrate:	Waterbody ID:				Longitude:
Marl?	Total # of Species				Max. Lakeward Extent of Bed
High Organic?	**CanopyAbundance at Site**				Latitude:
	S:	N:	F:	E:	Longitude:

SPECIES INFORMATION

Species Code	Abundance	QE	Vchr.	Ref. ID

Individual Plant Bed Survey



Comments:

REMINDER INFORMATION

Substrate:
1 = Silt/Clay
2 = Silt w/Sand
3 = Sand w/Silt
4 = Hard Clay
5 = Gravel/Rock
6 = Sand

Marl
1 = Present
0 = absent

High Organic
1 = Present
0 = absent

Overall Surface Cover
N = Nonrooted floating
F = Floating, rooted
E = Emergent
S = Submersed

Canopy:
1 = < 2%
2 = 2-20%
3 = 21-60%
4 = > 60%

Abundance:
1 = < 2%
2 = 2-20%
3 = 21-60%
4 = > 60%

QE Code:
0 = as defined
1 = Species suspe
2 = Genus suspected
3 = Unknown

Voucher:
0 = Not Taken
1 = Taken, not varified
2 = Taken, varifie

Reference ID:
Unique number or letter to denote specific location of a species; referenced on attached map

Appendix B.

Explanations of Fields on the Aquatic Vegetation
Waterbody Cover Sheet

Surveying Organization	Name of agency, corporation, group, individual, etc. that is collecting the data
Waterbody name	Common name of the lake or stream. Name should be consistent with the name found on most maps of the given waterbody (e.g. Lake Lemon, not Lemon Lake).
Lake ID	Unique State assigned alphanumeric code for the specific waterbody. Available through IDNR, Division of Fish & Wildlife.
County(s)	Name of the county(s) where sampling was conducted. When the waterbody or stream section traverses more than one county, list the primary county (county with the greatest acreage of water) first.
Date	The month (MM), day (DD), and year (YYYY) on which a site was sampled. Zeros (0) must be written in so that the date has eight digits.
Habitat stratum	Each stratum code defines a unique, major aquatic geomorphic feature in the state of Indiana. The habitat stratum of the site according to the above protocol is an important ecological consideration, as well as, valuable for the purposes of stratifying future sampling. The letter codes are listed in Table 1.
Average Depth	Average depth of the lake. Reference bathymetric maps, state personnel, historic studies etc.
Lake Level	Lake level at the time of sampling
Crew leader code	The full name or ID number that uniquely identifies the individual responsible for certifying that the samples and the data on the form were collected in compliance with current protocol and are, to the best of their knowledge, complete and free of errors. This identifying field underscores the importance of above method and is an important chain-of-custody procedure.
Recorder code	A name or number or initials that uniquely identifies the individual recording the data on the data sheets.
Datum	One or more constants used for calculating positions or elevations. These series of constants are commonly referred to as NAD'83, NAD'27, WGS'84, etc.
Zone	The number that identifies the correct grid from which the coordinates were taken. All of the State of Indiana falls into Zone 16.

Accuracy	The GPS measure of possible error related to the geometry of satellites. This number value is recorded when the Lat/Long coordinates are recorded. The method field indicates whether the scale is PDOP (Percent dilution of precision) or FOM (Figure of Merit).
Method	A code that identifies the method used to locate the site and the type of accuracy measurement used by the equipment. B = Base Map D = GPS with differential corrections and PDOP G = GPS without differential corrections and PDOP F = GPS with differential corrections and FOM X = GPS without differential corrections and FOM O = other (explain)
Secchi Depth	Secchi depth is taken and recorded (feet) at a mid plant bed site as soon as depth allows and distance from shore is deemed appropriate.
Total # of Plant Beds	Number of plant beds surveyed on the particular lake/stream as part of this sampling effort.
Total # of Species	The total number of unique records (rows) in **SPECIES INFORMATION** on the data sheets from all beds. This number represents the species diversity for the entire waterbody.
Littoral Zone Size	Size (acres) of the entire littoral zone may be measured through a variety of mapping techniques or estimated by the surveyors. The method is then noted.
Littoral Zone Max. Depth	Maximum littoral depth may be measured at a variety of locations in the field and averaged or estimated through the use of current or historical Secchi disk data. The extent of the littoral zone can be determined by multiplying the average or current Secchi depth by three. The method is then noted.
Notable Conditions	Comments that describe any unusual weather or water quality conditions that may interfere with accurate sampling such as rain, strong winds, algal blooms, etc.

Explanations of Fields on the Aquatic Vegetation

Plant Bed Data Sheet

Organization name	Name of agency, corporation, group, individual, etc. that is collecting the data
Date	The month (MM), day (DD), and year (YYYY) on which a site was sampled. Zeros (0) must be written in so that the date has eight digits.

SITE INFORMATION

Waterbody name	Common name of the lake or stream. Name should be consistent with the name found on most maps of the given waterbody (e.g. Lake Lemon, not Lemon Lake).
Waterbody ID	Unique State assigned alphanumeric code for the specific waterbody. Available through IDNR, Division of Fish & Wildlife.
Plant Bed ID	Two-digit number assigned to uniquely identify each bed/site. Accuracy of the Plant Bed ID is critical because it links field data to be collected with data already available in the database. A zero must be written before the number so the ID # is a two-digit number starting with "01".
Substrate	A qualitative code assigned to substrate type following tactile and visual examination of sediment at the sampling site. Substrate is rated on a scale of 1 to 6 according to Table 5.
Marl	A "1" identifies the presence of a marl (calcium carbonate) sediment. The default is a "0".
High Organic	A "1" identifies the presence of coarse organic material in the sediment. The default is a "0".
Total # of Species	The total number of detail records (rows) in **SPECIES INFORMATION** that contain data on this particular data sheet.
Cover	S = Percent canopy abundance of all submersed 'topped-out' species combined for the bed using the ratings described in Table 4. N = Percent canopy abundance of all nonrooted floating-leaved species combined for the bed using the ratings described in Table 4. F = Percent canopy abundance of all rooted floating-leaved species combined for the bed using the ratings described in Table 4.

E = Percent canopy abundance of all emergent species combined for the bed using the ratings described in Table 4.

SITE COORDINATES (Recorded when the approximate center of the plant bed is determined and the furthest lakeward extent is known.)

Latitude — The latitude coordinate for the site (either center or extent). The coordinate is recorded via a GPS unit after plant bed boundaries are estimated.

Longitude — The longitude coordinate for the site (either center or extent). The coordinate is recorded via a GPS unit after plant bed boundaries are estimated.

SPECIES INFORMATION

Species code — The alphanumeric six letter code for a species. Most of the species codes are available in Appendix C. If the genus of a plant is known and species unknown, then a new code is made up with the first four letters of the genus name and a '?' (question mark) inserted between the second and third letters. For examples, "PO?TA "for *Potamogeton* sp., and "MY?RI" for *Myriophyllum* sp. Using the species code of a suspected species is preferable, however, when based on the suggestion of the vegetation specialist. The confidence level of identification will be reflected in the **QE** code.

Abundance — A number (1-4) that represents the percent abundance of a particular species in the community at the bed/site using the ratings described in Table 2.

QE — A number (0–3) used to flag the taxonomic identification uncertainty (Table 3).

Voucher — A code denoting whether a voucher specimen was taken of the species.
0 = no voucher taken
1 = voucher taken, and not sent out for identification
2 = voucher taken, and sent out for identification

Reference ID — A number or letter that denotes a specifics location of a species of concern. The number or letter is referenced on an attached map showing the approximate location(s).

Comments — A field for recording any additional observations. Limit comments to 100 characters.

REMINDER INFORMATION (Abbreviated glossary of codes used in the data fields.)

Appendix C. Species Codes

Species Code	Scientific Name	Common Name	Vegetation Type
ALGA	Any species of filamentous alga (incl. Spyrogyra, Cladophora, Hydrodictyon)	algae	NV
AZ?OL	*Azolla* sp.	a mosquito fern sp.	NV
AZCA	*Azolla caroliana*	Carolina mosquito fern	NV
AZME	*Azolla mexicana*	Mexican mosquito fern	NV
CEDE4	*Ceratophyllum demersum*	coontail	SB
CH?AR	*Chara* sp.	a chara sp.	SB
ELCA7	*Elodea canadensis*	Canadian waterweed	SB
ELNU2	*Elodea nuttalli*	western waterweed	SB
LEMN	Species within the Lemnaceae	duckweeds	NV
LEMI3	*Lemna minor*	small or common duckweed	NV
LETR	*Lemna trisulca*	star duckweed	NV
LUDE4	*Ludwigia decurrens*	primrose-willow	FL
LVWORT	*Riccia* sp., *Ricciocarpus* sp.	a liverwort species	NV
MYSI	*Myriophyllum sibiricum*	northern watermilfoil	SB
MYSP2	*Myriophyllum spicatum*	Eurasian watermilfoil	SB
MY?RI	*Myriophyllum*, unidentified species	a watermilfoil sp.	SB
NAFL	*Najas flexilis*	slender naiad	SB
NAGR	*Najas gracillima*	slender waternymph	SB
NAGU	*Najas guadalupensis*	southern waternymph	SB
NAMI	*Najas minor*	brittle waternymph	SB
NLPW	*Potamogeton foliosus*, *P. pusillus*, or other unidentified narrow-leaved pondweeds	narrow-leaved pondweeds	SB
NELU	*Nelumbo lutea*	American lotus	FL
NI?TE	*Nitella* sp.	a nitella sp.	SB

NOAQVG		no aquatic vegetation in site	NV
NULU	*Nuphar variegetum* (formerly N. luteum)	yellow pond lily	FL
NYTU	*Nymphaea tuberosa*	white water lily	FL
POAL8	*Potamogeton alpinus*	red or alpine pondweed	SB
POCR3	*Potamogeton crispus*	curly-leaf pondweed	SB
POEP2	*Potamogeton epihydrus*	ribbon-leaf pondweed	SB
POFO3	*Potamogeton foliosus*	leafy pondweed	SB
POGR8	*Potamogeton gramineus*	variable pondweed	SB
POIL	*Potamogeton illinoensis*	Illinois pondweed	SB
PONO2	*Potamogeton nodosus* (formerly *P. americanus*)	American pondweed	SB
POPE6	*Potamogeton pectinatus*	sago pondweed	SB
POPR5	*Potamogeton praelongus*	white-stemmed pondweed	SB
POPU7	*Potamogeton pusillus*	small pondweed	SB
PORI2	*Potamogeton richardsonii*	Richardson's pondweed	SB
POZO	*Potamogeton zosteriformis*	flat-stemmed pondweed	SB
RAFL	*Ranunculus flabellaris*	yellow water-cup (yellow water buttercup)	SB
RALO2	*Ranunculus longirostris* (incl. *R. trichophylus*)	white water-cup (rigid white water buttercup)	SB
SPPO	*Spirodela polyrhiza*	greater duckweed	NV
UNKN01		Unknown specimen No. 1	
UNKN02		Unknown specimen No. 2	
UTMA	*Utricularia vulgaris* (also known as *U. macrorhiza*)	common bladderwort	SB
VAAM3	*Vallisneria americana*	wild celery	SB
WO?LF	*Wolffia*, unidentified sp.	a watermeal sp.	NV
WOCO	*Wolffia columbiana*	watermeal	NV
ZAPA	*Zannichellia palustris*	horned pondweed	SB

ZODU	*Zosterella dubia* (also known as *Heteranthera dubia*)	water stargrass	SB

Procedure Manual for
Surveying Aquatic Vegetation:
Tier II Random Sampling

1. Monitoring Strategy for Aquatic Vegetation

The following protocol is currently being used by the IDNR Division of Fish and Wildlife to provide a quantitative sampling mechanism for aquatic plant surveying. Pearson (2004) provides additional details regarding the protocol and an example of its use to quantify the occurrence, distribution, and abundance of aquatic plants in 21 northern Indiana lakes. This protocol supplements the Tier I Reconnaissance Protocol for plant bed mapping. Together the protocols should serve to meet the following objectives:

1. to document the distribution and abundance of submersed and floating-leaved aquatic vegetation within selected areas;
2. to compare present distribution and abundance with past distribution and abundance within select areas.

Aquatic vegetation is monitored in an assortment of lakes and streams across the state as part of a variety of projects. The following procedure is applicable for State sponsored surveys, coordinated fisheries management, pre-treatment and post-treatment herbicide application, and possibly for volunteer monitoring. All of the data collected through the use of this protocol will be recorded on standardized data sheets (Appendix A) and a copy filed with the Department of Natural Resources Division of Fish & Wildlife.

1.1 Habitat Stratification

The areas/waterbodies to be surveyed are divided into strata and subjected to discrete sampling efforts to increase efficiency, effectiveness, and knowledge of habitat influence on plant communities. Each stratum represents a major aquatic geomorphic feature in the State of Indiana (Table 1). A few other strata are not sampled. The main navigation channel on the Ohio River and other deepwater areas within selected lakes or rivers (>6 m deep) are not sampled because aquatic vegetation is unlikely to grow in these areas in the prevailing water quality conditions. In addition, the aquatic areas near dams and/or spillways are not sampled because of safety considerations. Refer to Table 1 when categorizing the sampled stratum.

Table 1. Aquatic Area Strata and Codes

Stratum Description	Stratum Code
Inland Lake	IL
Inland Reservoir	IR
Lake Michigan	LM
First Order Stream	FOS
Second Order Stream	SOS
Third Order Stream	TOS
Fourth Order Stream	FROS
Fifth Order Stream	FHOS
None	NA

* When "None" is selected, describe the habitat type in the comments section of the data sheet.

1.2 Sampling Sites Selection

Before conducting random sampling, a preliminary reconnaissance of the area is conducted according to the Indiana Reconnaissance Survey Protocol (Shuler & Hoffmann 2002). The littoral zone and plant beds identified in the reconnaissance survey are sampled in the present survey using a stratified random methodology. In order to ensure that randomly selected sampling points are well distributed throughout the littoral zone of the lake, sample sites are apportioned to each plant bed based on the proportion of the total littoral zone that is comprised by each plant bed. The number of sampling points for each waterbody is based on the surface area of the lake (Table 2). For example, if a 200-acre lake is found to have four plant beds of roughly equal size, then each plant bed would be sampled at 15 randomly selected sites. No plant bed should be sampled at fewer than five sites.

Table 2. Number of Sample Sites Based on Waterbody Size

Size of Waterbody	Number of Sample Sites
1-100 acres	40
101-300 acres	60
Greater than 300 acres	Add 10 sites/100 acres

1.3 Sampling efforts and schedule

Sampling is conducted twice during the growing season, in order to describe phenological changes. The first (or spring) sampling is conducted between 15 May and 15 June, and the second (or summer) sampling occurs between 15 July and 15 August. If time and resources only allow one sampling event, that event should occur between 15 July and 31 August. The minimum number of sampling sites at any given water body is 40.

Water temperature, as well as calendar date, are used to determine when the spring sampling occurs. If surface water temperature is >18°C on 15 May, then sampling can begin. However, if water temperature is <18°C on 15 May, then it is monitored and sampling delayed until temperatures reach the 18°C threshold. If water temperatures remain low two weeks later (29 May), then sampling can be initiated regardless of water temperature in order to complete spring sampling within the sampling window (before 15 June).

1.4 Equipment and Definitions

A sampling rake (Figure 1) is used for collecting vegetation samples. The sampling rake is essentially a double-headed garden rake attached to a rope (Deppe and Lathrop 1992). It has a 36 cm (13.5 inch) wide head, has 14, 5-cm long (2.25 inch) teeth on each side spaced 0.75 inches apart, and is made by welding two square-headed garden rakes together. The rake head is marked into five equal parts (or 20% increments). The rake head is attached to a rope that is scaled at 1 foot increments (red marks every five feet) so that it can be used to measure water depth.

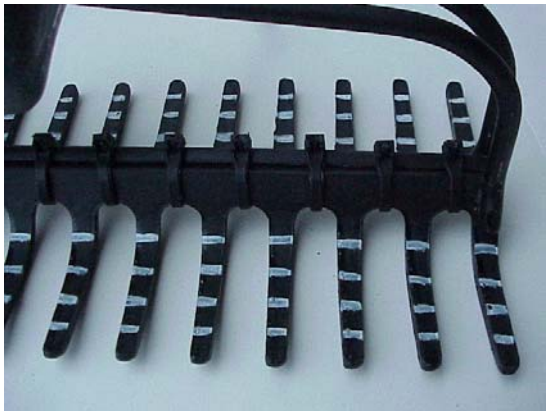


Figure 2: Double-headed rake for aquatic vegetation sampling

Most of the sampling is conducted by boat. The sampling procedures are designed in reference to a regular 16-ft boat, which is approximately 5 m long and 2 m wide.

Throughout the procedure manual, aquatic vegetation or aquatic species refer to the following plant types: submersed (S), rooted floating-leaved (F), nonrooted floating-leaved (N), and emergent (E). The nonrooted floating-leaved category is composed of *Lemnaceae* and *Azolla* sp. Filamentous algae are treated as if they were a single species.

2. Sampling

A cover sheet is completed for each water body. If an erroneous entry is made, mark a line (or lines) through the field, fields, or entire record, whichever is appropriate and record initials next to the deletion. To change a field value, line out the incorrect data, enter the corrected value next to it and initial the correction. All data fields on the data sheets are explained in detail in Appendix B.

Begin the sampling effort by recording general water body information on the water body cover sheet. Some fields (such as **Total # of Species**) will remain blank until the all sites have been sampled. The sampling operation is composed of multiple steps, beginning with recording **Site information**.

Step 1. Submersed aquatic plants should be sampled during the last week of July or the first two weeks of August if only one sample is to be taken. If an early season sample is to be taken conduct sampling during the last week of May or the first two weeks of June. Record at least one secchi disk reading offshore.

Step 2. Pre-determine random sampling points or locate random points in a haphazard, zig-zag pattern throughout the littoral zone at various depths from the shore to the maximum depth of plant growth. Record the maximum depth of the littoral zone. The littoral zone was previously identified, stratified by plant community structure and composition, and mapped during Tier 1 sampling. The number of sample points is dependent on lake size and is given in Table 2. The number of sampling locations apportioned to each of the plant beds identified in Tier 1 surveys should be based upon the proportion of the total littoral zone composed by each plant bed.

Step 3. Stop the boat at each sampling point. Anchoring the boat is not necessary. Record or log as a waypoint the GPS coordinates of the site.

Step 4. Drop a double-sided weighted weed rake (see Pearson 2004 for description) attached to a rope pre-measured in one-foot intervals (red marks every five feet) off the bow of the boat straight to the lakebed. Record water depth.

Step 5. After water depth is measured, an additional 10 feet of rope is released and held at the bow of the boat. Operate the boat in reverse at minimum operating speed for a distance of ten feet of additional rope length held firmly at the bow of the boat. Then drag the weed rake to the boat with moderate force with the outboard still in reverse. The boat is typically backed in the opposite direction as it had approached the site unless there is wind, in which case the boat is backed with the direction of the wind.

Step 6. Score the overall plant abundance on the rake, marked off in five equal sections on the tines (Figure 2). Pile all vegetation hanging down from the rake onto one side for a score of 1-5. Vegetation density ratings are listed in Table 3. Ensure that the thickness of the vegetation is generally less that one inch on either side of the rake and that visible "holes" are filled. Thickness should be minimized. Do not overly pack the plants on the rake.

Table 3. Vegetation Density Ratings[a]

Rake teeth filled (%)	Density rating
81-100	5
61-80	4
41-60	3
21-40	2
1-20	1
No plants retrieved	0

[a]Ratings are modified from Deppe and Lathrop (1992).

Step 7. Separate the various plant species and place on the rake for an abundance score of 1-5 under various acronym headings listed on the form. Small tubs are convenient for separating each species prior to scoring their densities. When re-piling various plant species back on the rake, spread them evenly on one side of the rake across the complete row of tines as described in Step 6. Record the abundance score on the datasheet. Use a single row on the data form to record each site.

Step 8. Plant of questionable identification should be saved in plastic bags, given a voucher number, their abundance recorded at each site on the datasheet, and placed in a cooler with ice.

Step 9. Note the presence of filamentous algae on the rake (record "p"). Note the presence of any other species at any time in the lake. Voucher specimens are collected for any species of which the identity is uncertain or unknown, or a species that is known not to be in the state herbarium.

Step 10. If a voucher specimen is collected for subsequent identification, put a "V" followed by the number of the voucher (i.e., 1, 2, 3…) in the **species code** box. Voucher specimens should include multiple specimens of the same suspected species (3-5 specimens with all available morphological characteristics, flowers, fruits, etc. included)

Step 11. Record the number of rows with information (from the **Species information** area) in the **# of Species** box near the top of the site data sheet.

Step 12. Upon completion of all sample sites, record any outstanding waterbody summary data (such as **Total # of Species**) on the waterbody cover sheet and attach all data sheets to this cover sheet.

2.3 Unusual situations

No aquatic vegetation:

If a sample site has no aquatic vegetation, regardless of the reasons, put "NOAQVG" in the **Species Code** box.

Filamentous algae only:

If only filamentous algae is collected at a site, **Site** and **Depth**. **Species** is recorded as ALGA, assign a visual abundance rating, leave the rake boxes blank.

Inaccessible sites:

If a site cannot be accessed, put "NOSMPL" in the **Species Code** box. Record the UTM coordinates of the boat stop location and the reason for not sampling in the "Comments" field.

Unable to rake:

If physical conditions such as depth and current velocity preclude raking the bottom for aquatic vegetation, the site should be treated the same as *Inaccessible sites* described above. However, the same physical conditions often preclude the existence of aquatic vegetation. The investigators are encouraged to make a careful assessment of the probability of aquatic vegetation growth under the conditions. If the probability is less than 5%, the site should be treated the same as *No aquatic vegetation* described above. Record the reason for not raking in the **Comments** field.

3. Taxonomy and Species Codes

Whenever possible, identify plants to the species level using the following taxonomic keys: Fassett (1957), Voss (1972, 1985), and Gleason and Cronquist (1991). Many of the common aquatic species found in Indiana are listed in Appendix C. Species codes not available in Appendix C are determined by using the first three letters of the genus name followed by the first three letters of the species name. If the genus of a plant is known and species unknown, make up a new code with the first four letters of the genus name and a '?' (question mark) inserted between the second and third letters—for example, "PO?TA" for *Potamogeton* sp. and "MY?RI" for *Myriophyllum* sp. (Using a taxon suggested by the vegetation specialist is preferable.) If the genus is unknown, make a unique code (e.g., "UNKN01", "UNKN02", etc.) for each unknown taxon. Collect two or more voucher specimens for each uncertainly identified or unknown plant for follow-up identification in the office or by external taxonomists. Upon positive identification, uncertain and unknown species codes will be confirmed or replaced with new codes.

4.0 Data & Equipment Management

All data sheets are identified with the sampling organization's name and waterbody name. Photocopies are made of all data sheets. The photocopied data sheets are mailed to the Department of Natural Resources Division of Fish & Wildlife. All originals are retained by the sampling organization.

Exotic, threatened or endangered species should be recorded on the data sheet and noted on the reconnaissance map. The presence of such species should also be recorded on the Indiana Special Plant Survey Form (See Appendix A) and sent to the IDNR Division of Nature Preserves.

Voucher specimens are collected and directed to the attention of Dr. Robin Scribailo at Purdue-North Central.

To avoid the spread of exotic species, survey crews should insure that all traces of aquatic vegetation are removed from boats, motors, and sampling gear before surveying other lakes/streams.

5.0 References Cited

Deppe, E.R., and R.C. Lathrop. 1992. A comparison of two rake sampling techniques for sampling aquatic macrophytes. Findings 32, Wisconsin Department of Natural Resources, Madison, Wisconsin.

Fassett, N.C. 1957. A Manual of Aquatic Plants. University of Wisconsin Press, Madison, Wisconsin.

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Canada, Hafner Press, New York.

Pearson, J. 2004. A sampling method to assess the occurrence, abundance, and distribution of submersed aquatic plants in Indiana lakes. Indiana Department of Natural Resources, Division of Fish and Wildlife, Indianapolis, Indiana. 37pp.

Shuler, S. and J.E. Hoffmann. 2002. Procedure manual for aquatic vegetation reconnaissance surveying. Indiana Department of Natural Resources, Division of Soil Conservation, Indianapolis, Indiana. 7p.

Voss, E.G. 1972. Michigan Flora Part I: Gymnosperms and Monocots. Cranbrook Institute of Science, Bloomfield Hills, Michigan.

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APPENDIX A

Submersed Aquatic Plant Survey Form

Page ____ of _____

WATER BODY NAME			SECCHI	
COUNTY			MAX PLANT DEPTH	
DATE			WEATHER	
CREW LEADER			COMMENTS	
RECORDER				

Rake score (1-5), observed only (9), algae present (p)

Use acronyms for species, V1, V2…for voucher codes

					Species Code									Note
Site	Northing	Easting	Depth	All										
Other plant species observed at lake														

Quad Code:_____

Indiana Special Plant Survey Form

Element Name: _____

Surveyor (s): _____Date: _____ Time: ____ to _____

Location (lat/long in dec. degrees): _____ Quad name: _____

Repeat visit: Yes No Repeat visit needed: Yes No When: _____

EO boundaries mapped: Yes No County: _____

Area name (if applicable) _____

Biology

Phenology	Approx # Indiv	Population Area	Age Class
__In leaf	__ 1-10	__ 1 yd^2	__ % Seedlings
__In bud	__ 11-50	__1-5 yd^2	__% Immature
__In flower	__ 51-100	__5-10 yd^2	__% 1st year
__In fruit	__101-1000	__10-100 yd^2	__% Mature
__Seed Dispersing	__ 1001-10,000	__100 yd^2-2 ac	__%Senescent
__Dormant	__10,001+	__2 ac +	

Comments on above: _____

Compared to your last visit to this site:	Approx # Indiv	Population Area	Age Class
	__more	__more	__same
	__same	__same	__diff
	__less	__less	

Reproduction Is reproduction occurring?__ Type: __sexual, __asexual, __both

Show exact location and boundaries of taxon on map. (attach)

Population Distribution __ solitary, __clumps or dense groups, __small patches or cushions

__small colonies or large carpets, __large, almost pure population stands.

Vigor: 1) very feeble, 2) feeble, 3) normal, 4) exceptionally vigorous

Evidence of symbiotic or parasitic relationships:

Habitat

Aspect	Slope	Light	Topographic Position	Moisture
__N	__Flat	__Open	__Crest	__Inundated (Hydric)
__E	__0-10’	__Filtered	__Upper slope	__Saturated(Wet-mesic)
__S	__10-35’	__Shade	__Mid-Slope	__Moist (Mesic)
__W	__35’ +		__Lower slope	__Dry (Xeric)
	__Vertical		__Bottom	

Elevation: _____ft to _____ft. Surface Relief: ___/: ___∪:___∩:___—:___~~

Substrate/Soils: _____

Associated Natural Community/Plant Community: _____

List other members of this genus co-occurring at this site: _____

Characteristic associated species: _____

_____

Estimated size of potential Habitat: (as in population area) Boundaries mapped: yes no

---

Ownership info: (if known) _____

NOTE: Collect specimen if a healthy, viable population exists. Collection # _____

Appendix B.

Explanations of Fields on the Aquatic Vegetation Waterbody Cover Sheet

Organization name	Name of agency, corporation, group, individual, etc. that is collecting the data
Waterbody name	Common name of the lake or stream. Name should be consistent with the name found on most maps of the given waterbody (e.g. Lake Lemon, not Lemon Lake).
Lake ID	Unique State assigned alphanumeric code for the specific waterbody. Available through IDNR, Division of Fish & Wildlife.
County(s)	Name of the county(s) where sampling was conducted. When the waterbody or stream section traverses more than one county, list the primary county (county with the greatest acreage of water) first.
Date	The month (MM), day (DD), and year (YYYY) on which a site was sampled. Zeros (0) must be written in so that the date has eight digits.
Habitat stratum	Each stratum code defines a unique, major aquatic geomorphic feature in the state of Indiana. The habitat stratum of the site according to the above protocol is an important ecological consideration, as well as, valuable for the purposes of stratifying future sampling. The letter codes are listed in Table 1.
Average Lake Depth	Average depth of the lake. Reference bathymetric maps, state personnel, historic studies etc.
Lake Level	Lake level at the time of sampling
Crew leader code	The full name or ID number that uniquely identifies the individual responsible for certifying that the samples and the data on the form were collected in compliance with current protocol and are, to the best of their knowledge, complete and free of errors. This identifying field underscores the importance of above method and is an important chain-of-custody procedure.
Recorder code	Name or number or initials that uniquely identifies the individual recording the data on the data sheets.
Datum	A mathematical model describing the shape of the earth. **NAD 83** is the preferred datum.
Zone	The number that identifies the correct grid from which the coordinates were taken. All of the State of Indiana falls into Zone 16.
Accuracy	The GPS measure of possible error related to the geometry of satellites. This number value is recorded when the Lat/Long coordinates are recorded. The method field indicates whether the scale is PDOP (Percent dilution of precision) or FOM (Figure of Merit). For WAAS enabled GPS receivers indicate whether a differential correction signal was being received.

Method A code that identifies the method used to locate the site and the type of accuracy measurement used by the equipment.
B = Base Map
D = GPS with differential corrections and PDOP
G = GPS without differential corrections and PDOP
F = GPS with differential corrections and FOM
X = GPS without differential corrections and FOM
W = GPS with WAAS enabled
O = other (explain)

Secchi Depth — Secchi depth is taken and recorded in feet offshore where depth allows and distance from shore is deemed appropriate.

Total # of Sites — Number of sites surveyed on the particular lake/stream as part of this sampling effort.

Total # of Species — The total number of species observed at the site. This number represents the species richness for the entire waterbody.

Littoral Zone Size — Size (acres) of the entire littoral zone may be measured through a variety of mapping techniques or estimated by the surveyors. The method is then noted.

Littoral Zone Max. Depth — Maximum littoral depth may be measured at a variety of locations in the field and averaged or estimated through the use of current or historical Secchi disk data. The extent of the littoral zone can be determined by multiplying the average or current Secchi depth by three (See Shuler & Hoffmann 2002). The method is then noted.

Notable Conditions — Comments that describe any unusual weather or water quality conditions that may interfere with accurate sampling such as rain, strong winds, algal blooms, etc.

Explanations of Fields on the Aquatic Vegetation
Site Data Sheet

Organization name	Name of agency, corporation, group, individual, etc. that is collecting the data
Date	The month (MM), day (DD), and year (YYYY) on which a site was sampled. Zeros (0) must be written in so that the date has eight digits.

SITE INFORMATION

Waterbody name	Common name of the lake or stream. Name should be consistent with the name found on most maps of the given waterbody (e.g. Lake Lemon, not Lemon Lake).
County	The county where the water body principally is located.
Site ID	Two-digit number assigned to uniquely identify each site. Accuracy of the Site ID is critical because it links field data to be collected with data already available in the database. A zero must be written before the number so the ID # is a two-digit number starting with "01".
Crew leader code	The full name or ID number that uniquely identifies the individual responsible for certifying that the samples and the data on the form were collected in compliance with current protocol and are, to the best of their knowledge, complete and free of errors. This identifying field underscores the importance of above method and is an important chain-of-custody procedure.
Recorder code	Name or number or initials that uniquely identifies the individual recording the data on the data sheets.
Secchi depth	Secchi depth is taken and recorded (feet) at a mid plant bed sight as soon as depth allows and distance from shore is deemed appropriate.
Maximum plant depth	The maximum depth at which plants are found.
Weather	Record weather conditions
Comments	A field for recording any additional observations.

SITE COORDINATES

Northing	The UTM northing coordinate for the site. The coordinate is recorded from a GPS unit when first arriving at the site.
Easting	The UTM easting coordinate for the site. The coordinate is recorded from a GPS unit when first arriving at the site.

SPECIES INFORMATION

Species code	The alphanumeric six character code for a species. Many of the common species codes are available in Appendix C. If the genus of a plant is known and species unknown, then a new code is made up with the first four letters of the genus name and a '?' (question mark) inserted between the second and third letters. For examples,

"PO?TA "for *Potamogeton* sp., and "MY?RI" for *Myriophyllum* sp. Using the species code of a suspected species is preferable, however, when based on the suggestion of the vegetation specialist.

R — Record under the species code a number (1–5) for plant density measurement rated according to Table 3 for each submersed species found in the rake sample of vegetation. A floating-leaved or emergent species receives a "1" regardless of its plant density as long as the species was collected in the rake sample of vegetation. Record species not sampled by the rake at the bottom of the page.

Appendix C. Species Codes

Species Code	Scientific Name	Common Name	Vegetation Type
ALGA	Any species of filamentous alga (incl. Spyrogyra, Cladophora, Hydrodictyon)	algae	NV
AZ?OL	*Azolla* sp.	a mosquito fern sp.	NV
AZCA	*Azolla caroliana*	Carolina mosquito fern	NV
AZME	*Azolla mexicana*	Mexican mosquito fern	NV
CEDE4	*Ceratophyllum demersum*	coontail	SB
CH?AR	*Chara* sp.	a chara sp.	SB
ELCA7	*Elodea canadensis*	Canadian waterweed	SB
ELNU2	*Elodea nuttalli*	western waterweed	SB
LEMN	Species within the Lemnaceae	duckweeds	NV
LEMI3	*Lemna minor*	small or common duckweed	NV
LETR	*Lemna trisulca*	star duckweed	NV
LUDE4	*Ludwigia decurrens*	primrose-willow	FL
LVWORT	*Riccia* sp., *Ricciocarpus* sp.	a liverwort species	NV
MYSI	*Myriophyllum sibiricum*	northern watermilfoil	SB
MYSP2	*Myriophyllum spicatum*	Eurasian watermilfoil	SB
MY?RI	*Myriophyllum*, unidentified species	a watermilfoil sp.	SB
NAFL	*Najas flexilis*	slender naiad	SB
NAGR	*Najas gracillima*	slender waternymph	SB
NAGU	*Najas guadalupensis*	southern waternymph	SB
NAMI	*Najas minor*	brittle waternymph	SB
NLPW	*Potamogeton foliosus*, *P. pusillus*, or other unidentified narrow-leaved pondweeds	narrow-leaved pondweeds	SB
NELU	*Nelumbo lutea*	American lotus	FL
NI?TE	*Nitella* sp.	a nitella sp.	SB
NOAQVG		no aquatic vegetation in site	NV
NULU	*Nuphar variegetum* (formerly N. luteum)	yellow pond lily	FL

NYTU	*Nymphaea tuberosa*	white water lily	FL
POAL8	*Potamogeton alpinus*	red or alpine pondweed	SB
POCR3	*Potamogeton crispus*	curly-leaf pondweed	SB
POEP2	*Potamogeton epihydrus*	ribbon-leaf pondweed	SB
POFO3	*Potamogeton foliosus*	leafy pondweed	SB
POGR8	*Potamogeton gramineus*	variable pondweed	SB
POIL	*Potamogeton illinoensis*	Illinois pondweed	SB
PONO2	*Potamogeton nodosus* (formerly *P. americanus*)	American pondweed	SB
POPE6	*Potamogeton pectinatus*	sago pondweed	SB
POPR5	*Potamogeton praelongus*	white-stemmed pondweed	SB
POPU7	*Potamogeton pusillus*	small pondweed	SB
PORI2	*Potamogeton richardsonii*	Richardson's pondweed	SB
POZO	*Potamogeton zosteriformis*	flat-stemmed pondweed	SB
RAFL	*Ranunculus flabellaris*	yellow water-cup (yellow water buttercup)	SB
RALO2	*Ranunculus longirostris* (incl. *R. trichophylus*)	white water-cup (rigid white water buttercup)	SB
SPPO	*Spirodela polyrhiza*	greater duckweed	NV
UNKN01		Unknown specimen No. 1	
UNKN02		Unknown specimen No. 2	
UTMA	*Utricularia vulgaris* (also known as *U. macrorhiza*)	common bladderwort	SB
VAAM3	*Vallisneria americana*	wild celery	SB
WO?LF	*Wolffia*, unidentified sp.	a watermeal sp.	NV
WOCO	*Wolffia columbiana*	watermeal	NV
ZAPA	*Zannichellia palustris*	horned pondweed	SB
ZODU	*Zosterella dubia* (also known as *Heteranthera dubia*)	water stargrass	SB